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Original Article

Prevalence of Raynaud's Phenomenon and Countermeasures for Workers Using an Impact Wrench

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Summary: The aim of the present study was to clarify an association between the prevalence of Raynaud's phenomenon in workers using an impact wrench and the effect of various countermeasures to prevent adverse health effects of vibration over a period of 27 yr. The subjects were 704 workers who were regularly using an impact wrench and taking special medical examinations for vibration syndrome in a factory from 1981 to 2008. Practical countermeasures, such as improvement of an apparatus and control of working conditions, were taken twenty times. There were 39 subjects with Raynaud's phenomenon at least one time during the observation period. The prevalence of Raynaud's phenomenon decreased after introduction of the improved impact wrench. Thereafter, the prevalence of Raynaud's phenomenon remained to be about 2–5 % although various countermeasures were taken to keep the working environments warm, reduce the working time, and improve other working conditions. These findings showed that it is necessary to decrease the vibration level of an impact wrench to decrease the prevalence of Raynaud's phenomenon.

Keywords: Countermeasure, Impact wrench, Raynaud's phenomenon, Vibration level, Vibration syndrome

Introduction

Occupational exposure to vibration by hand-held vibrating tools causes vibration syndrome. The most prominent hand-arm vibration syndrome is Raynaud's phenomenon[1)]. Many cross-sectional and longitudinal investigations on vibration syndrome among workers using vibrating tools have been reported, and a dose-response relationship has been established between exposure to vibration and the occurrence of Raynaud's phenomenon on the basis of epidemiological studies[2-6)].

In previous study, we reported[7,8)] that introducing a vibration-proof impact wrench and keeping the working environments warm were effective in decreasing the symptoms and prevalence of abnormal findings in special medical examinations for vibration syndrome. In addition, it was also found that the prevalence of Raynaud's phenomenon decreased after introducing a vibration-proof impact wrench and Raynaud's phenomenon disappeared. Furthermore, in our previous study[9)], we reported that the estimated risk of developing Raynaud's phenomenon showed an exponential increase starting after 12 yr of operation under various countermeasures for workers using vibrating tools, because the vibration level of impact wrenches were high. However, little information is available on the prevalence of Raynaud's phenomenon under such conditions.

In this study, we focused on the prevalence of Raynaud's phenomenon for a period of 27 yr. The aim of this study was to clarify the association between the prevalence of Raynaud's phenomenon in workers using an impact wrench and the effect of various countermeasures to prevent adverse health effects of vibration.

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Subjects and Methods

Subjects

The subjects were all workers who occupationally use an impact wrench in a manufacturing factory for electric-light poles. The workers used an impact wrench to screw or unscrew bolts in the processes of molding and unmolding.

Special medical examinations for vibration syndrome began at the factory in 1981. They consisted of a primary medical examination and a secondary medical examination (Japanese Labour Standards Bureau Notification, No. 609[10]). Each subject was asked to complete a questionnaire regarding their work history, medical history and subjective symptoms, including Raynaud's phenomenon. All subjects using a vibrating tool were scheduled to take a special medical examination for vibration syndrome every year. However, some of them did not take the yearly special medical examination.

In this study, the data of the special medical examination were obtained from 1981 to 2008. One hundred seventy three workers took the special medical examination in 1981. A total number of 704 (685 male and 19 female) workers were selected as subjects. The ages of the subjects who took the first special medical examination ranged from 18 to 62 yr. The subjects in their forties constituted a majority (238 subjects), followed by those in their fifties (186 subjects) and those in their thirties (149 subjects). Seventy-eight subjects were in their twenties, and 51 subjects were in their teens. Two subjects were in their sixties. The mean age of those taking the first special medical examination was 40.8±11.4 (standard deviation) yr.

The protocol of this study was approved by the Ethics Committee of Wakayama Medical University.

Raynaud's phenomenon

In this study, a subject who was identified as having Raynaud's phenomenon in at least one finger on either hand or both hands was considered to be a worker with Raynaud's phenomenon. To identify Raynaud's phenomenon, a medical doctor asked the subject in detail about the site, frequency and factors related to Raynaud's phenomenon and showed them a photograph of typical Raynaud's phenomenon to confirm it. Judging from daily working conditions in addition to the information from each questionnaire, the medical doctor diagnosed the subject as having Raynaud's phenomenon due to vibration syndrome. Those who had Raynaud's phenomenon with a past history of accident, injury of the fingers or hand and so on were diagnosed as having traumatic Raynaud's phenomenon.

Forty-two of the 704 examinees were identified as having Raynaud's phenomenon. Three subjects with traumatic Raynaud's phenomenon were excluded. In this study, 39 workers were selected as subjects who had had Raynaud's phenomenon at least one time during the observation period. Their ages ranged from 35 to 59 yr. The mean age was 49.2±7.3 yr. The operating years at the time of occurrence of Raynaud's phenomenon ranged from 7 to 42 yr, and the mean was 25.5±8.3 yr. The majority of operating years were between 20 and 24 yr (11 subjects). Two subjects showed exceptionally long operating years exceeding 40 yr. Each subject was also asked to complete a questionnaire on the amount of time per day and days per year they spent using an impact wrench. Their answers were 2.6±2.0 h per day and 216.0±54.2 days per year on average.

Table 1. The Stockholm Workshop scale for classification of cold-induced Raynaud's phenomenon in the hand-arm vibration syndrome

Stage	Grade	Description
0		No attacks
Ⅰ	Mild	Occasional attacks affecting only the tips of one more fingers
Ⅱ	Moderate	Occasional attacks affecting distal and middle (rarely also proximal) phalanges of one or more fingers
Ⅲ	Severe	Frequent attacks affecting all phalanges of most fingers
Ⅳ	Very severe	As in stage Ⅲ, with trophic skin changes in the finger tips

The staging is made separately for each hand. In the evaluation of the subjects, the grade of the disorder is indicated by the stages of both hands and the number of affected fingers on each hand; example: "2L(2)/1R(1)","-/3R(4)", etc.

Stages of Raynaud's phenomenon

The stages of Raynaud's phenomenon were classified according to the Stockholm Workshop scale[11] (Table 1). The subjects were evaluated as being in the highest stage of Raynaud's phenomenon they attained during the observation period.

Countermeasures

We asked health supervisors at the factory to show us records about various countermeasures. We received a document on how to improve the tools or the working environment and when they carried out the countermeasures.

Table 2. Number of examinees and cases with Raynaud's phenomenon and prevalence of Raynaud's phenomenon per year from 1981 to 2008

Year	Number of examinees (n)	Number of cases with Raynaud's phenomenon (n)	Prevalence of Raynaud's phenomenon (%)
1981	173	0	0.0
1982	172	1	0.6
1983	175	4	2.3
1984	148	4	2.7
1985	135	6	4.4
1986	60	7	11.7
1987	97	6	6.2
1988	119	3	2.5
1989	119	2	1.7
1990	109	5	4.6
1991	105	5	4.8
1992	121	4	3.3
1993	204	10	4.9
1994	247	9	3.6
1995	274	6	2.2
1996	204	5	2.5
1997	184	7	3.8
1998	190	6	3.2
1999	172	8	4.7
2000	176	4	2.3
2001	168	6	3.6
2002	160	4	2.5
2003	126	2	1.6
2004	123	5	4.1
2005	89	3	3.4
2006	82	2	2.4
2007	75	3	4.0
2008	82	4	4.9

Results

Table 2 shows the number of examinees who took special medical examinations for vibration syndrome and the number of cases with Raynaud's phenomenon per year for 1981-2008. These data show the prevalence of Raynaud's phenomenon among the examinees.

The number of examinees was especially low in 1986, because those who had no abnormal findings in the last examination were not required to take a special medical examination. As the total number of employees at the factory gradually decreased, the number of subjects who took a special medical examination also decreased. No examinee was found to have Raynaud's phenomenon in 1981. The prevalence of Raynaud's phenomenon was 0.6 % in 1982. This increased gradually after 1982 and reached its peak value (11.7 %) in 1986. The prevalence of Raynaud's phenomenon ranged from 2 % to 5 % since 1988.

On the Stockholm Workshop scale, 19 subjects were classified to be in Stage Ⅰ, 19 subjects in Stage Ⅱ, and one subject in Stage Ⅲ. No subject was found to be in Stage Ⅳ.

Table 3 shows the objects and practical countermeasures to prevent adverse health effects of vibration. The first countermeasures started in 1973 at the factory. To decrease exposure to vibration, improvements of an apparatus such as suspending an impact wrench using a balancer were performed in 1987 and 1988. Reduction of the working time was performed nine times. The countermeasures to keep the working environments warm were conducted seven times. Improvement of the working condition was done twice.

The prevalence of Raynaud's phenomenon from 1981 to 2008 was summarized in Fig 1. The apparatuses, such as a balance to suspend an impact wrench, were introduced from 1987 to 1988. Since then, the prevalence of Raynaud's phenomenon decreased to be about 2–5 %.

Discussion

The results of this study showed that the prevalence of Raynaud's phenomenon decreased after the use of a balancer to suspend the impact wrench from 1987 to 1988. In addition, various countermeasures were made to keep the working environments warm and improve other working conditions. However, unlike our previous report[8], technical improvements in the motors of the impact wrench and introduction of a vibration-proof impact wrench were not done during the study period. Then, the prevalence of

Table 3. The objects and practical countermeasures to prevent adverse health effects of vibration

No. of countermeasures	Years	Objects	Practical countermeasures
①	1973, 1990	Reduction of working time	A mold unnecessary to screw in bolts was introduced.
②	1987–1988	Decrease of exposure to vibration	An impact wrench was suspended by a balancer so that the handle does not need to be held while working.
③	1988–1989	A warm working environment	An impact wrench with an air-heated warm handle was introduced to keep hands warm while working.
④	1989–1993	A warm working environment	A hot well was set up for washing hands in warm water.
⑤	1995	Reduction of working time	An apparatus was set up to automatically screw in bolts.
⑥	1996, 1998	Reduction of working time	An apparatus was set up to automatically screw in or unscrew bolts.
⑦	1996–1999	Reduction of working time	An apparatus was set up to automatically unscrew bolts.
⑧	2005	Improvement of working condition	A vibration-proof glove was promoted to protect hands while holding tool handles.
⑨	2006	Improvement of working condition	A compressed air was decreased.

Raynaud's phenomenon continued to be about 2-5 %.

Technical improvements in the motors of vibrating tools and introduction of vibration-proof vibrating tools have drastically reduced the frequency-weighted vibration acceleration in the handles of some vibrating tools[12,13]. The frequency-weighted vibration acceleration in the handle of a chain saw[14,15], for example, was reduced from 20 m/s^2 to 2-3 m/s^2. Longitudinal studies[16] on the effect of changes in vibration acceleration of a chain saw showed a decrease in the occurrence of Raynaud's phenomenon.

The committee on vibration syndrome of the Japan Society for Occupational Health[17] recommended the occupational exposure limit value for preventing adverse health effects on workers caused by occupational exposure

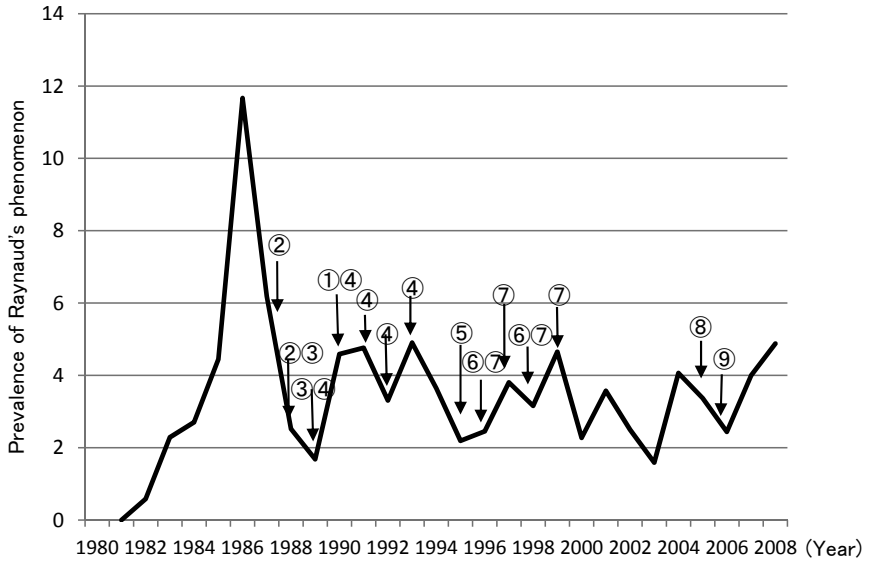

Fig. 1. Prevalence of Raynaud's phenomenon among examinees who took a special medical examination from 1982 to 2008. Arrows refer to countermeasures shown in Table 3.

to hand-arm vibration. The measured frequency-weighted vibration acceleration levels were over the occupational exposure limit value[9] in most impact wrenches. Furthermore, a new guideline[18] was recommended in Japan in 2009 to protect workers using hand-arm vibrating tools. A(8) was defined as a frequency-weighted acceleration of 8 hours per day according to the new guideline. More than half of calculated values of A (8) of the impact wrenches were over the exposure limit value[9].

The vibration level of the impact wrench is high compared with other hand-held vibrating tools[19]. One of the important factors that caused Raynaud's phenomenon was the vibration level of the impact wrench. Our previous study[8] showed that prevalence of Raynaud's phenomenon decreased dramatically after introducing the vibration-proof impact wrench and Raynaud's phenomenon disappeared. This may be due to the decrease in vibration level provided by the vibration-proof impact wrench. In the present study, the vibration level of the impact wrench remained high and the prevalence of Raynaud's phenomenon continued to be 2-5 %. This may result from the higher vibration level.

In the present study, working environment controls such as technical improvement in the motors of impact wrenches and the introduction of a vibration-proof impact wrench were not performed, although countermeasures for work control were taken many times. Under such conditions, the prevalence of Raynaud's phenomenon did not disappear. It could be speculated that improvement of an apparatus, such as suspending it with a balancer, was not sufficient to resolve Raynaud's phenomenon.

Various countermeasures were also taken to keep the working environments warm and reduce the working time. Furthermore, wearing vibration-proof gloves was promoted and compressed air was decreased to prevent adverse health effects of vibration. Iwata et al.[20] reported that the prevalence of Raynaud's phenomenon among workers using chain saws was lowered when they were protected against exposure to cold. Although protecting workers from cold exposure was also an important factor, it was insufficient to decrease the prevalence of Raynaud's phenomenon. Countermeasures were also taken to reduce the working time and improve working conditions. However, these were not effective to decrease the prevalence of Raynaud's phenomenon.

Our previous study[8] reported that the stages of Raynaud's phenomenon were mild in all subjects in a factory. This may also be an important factor in the disappearance of Raynaud's phenomenon. In this study, the stages of Raynaud's phenomenon of the workers were moderate and severe in more than half of the subjects. This may be one of the factors to keep the prevalence of Raynaud's phenomenon.

Our findings suggest that the vibration level should be decreased to protect adverse health effects of vibration because the improvement of an apparatus was not sufficient to decrease the prevalence of Raynaud's phenomenon. Furthermore, it is also speculated that the countermeasures such as reduction of working time and improvement of working conditions are not very effective to decrease the prevalence of Raynaud's phenomenon if the vibration level of an impact wrench was not decreased.

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インパクトレンチ作業者におけるレイノー現象の対策とその有病率の年次推移

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要　旨

インパクトレンチ取扱い作業者のレイノー現象は、振動工具の防振対策と寒冷対策により消失すること、さらに、防振対策を行わなければ寒冷対策を行っても振動工具取扱い開始から 12 年以降に発症することを報告してきた。そこで、本研究では、インパクトレンチ取扱い作業者に対して、レイノー現象の有病率を長期間観察し、振動障害の予防対策との関連について明らかにすることを目的とした。対象は、1981 年から 2008 年までの間に振動工具を取り扱う業務に係る特殊健康診断を受診した作業者 704 名である。対象者は、コンクリートを注入する電柱の鋳型を組み立てるあるいは外す際に、ボルトを締めるあるいは緩める作業でインパクトレンチを使用している。対策は振動工具を吊るす装置の改善の他、作業時間の低減や保温等の作業管理を含めて 20 回実施された。観察期間 27 年の間に 1 回でもレイノー現象を訴えた者は 39 名であった。振動工具を吊るす装置の改善によりレイノー現象の有病率は低下したものの、その後行った種々の対策の効果は見られず、レイノー現象の有病率は 2%～5%であった。インパクトレンチのような振動レベルの高い工具を取り扱う作業では、防振型の工具を導入する等の作業環境管理である工具の対策がレイノー現象の有病率の低下に最も効果的であり、保温等の作業管理を行うだけでは不十分であることが明らかとなった。レイノー現象の有病率を低減するには、工具の改善による振動レベルの低減を行うことが重要である。

キーワード：対策、インパクトレンチ、レイノー現象、振動レベル、振動症候群